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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 39.

B. T. GALLOWAY, *Chief of Bureau.*

U. S. DEPT OF AGRICULTURE
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THE PROPAGATION OF THE EASTER LILY FROM SEED.

BY

GEORGE W. OLIVER, EXPERT.

SEED AND PLANT INTRODUCTION AND DISTRIBUTION.

ISSUED JUNE 24, 1903.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

BULLETINS OF THE BUREAU OF PLANT INDUSTRY.

The Bureau of Plant Industry, which was organized July 1, 1901, includes Vegetable, Pathological, and Physiological Investigations, Botanical Investigations and Experiments, Grass and Forage Plant Investigations, Pomological Investigations, and Experimental Gardens and Grounds, all of which were formerly separate Divisions, and also Seed and Plant Introduction and Distribution, the Arlington Experimental Farm, Tea Culture Investigations, and Domestic Sugar Investigations.

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[Continued on p. 3 of cover.]

SEEDLING LILIES IN BLOOM, SIX MONTHS AND THIRTEEN DAYS AFTER GERMINATING.

A, Lilium longiflorum × L. harrisii; *B*, L. harrisii × L. longiflorum, showing large flower.

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BUREAU OF PLANT INDUSTRY.

BEVERLY T. GALLOWAY, *Chief of Bureau.*

SEED AND PLANT INTRODUCTION AND DISTRIBUTION.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 4, 1903.

Sir: I have the honor to transmit herewith a paper entitled "The Propagation of the Easter Lily from Seed," and respectfully recommend that it be published as No. 39 of the series of Bulletins of this Bureau.

This paper was prepared by Mr. George W. Oliver, Expert, and was submitted for publication by the Botanist in Charge of Seed and Plant Introduction and Distribution.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE PROPAGATION OF THE EASTER LILY FROM SEED.

THE BERMUDA LILY.

In the United States *Lilium harrisii* came into prominence nearly twenty-five years ago, a few bulbs being brought from the Bermudas about that time. These were propagated and their superiority for early forcing demonstrated. Elwes, in his monograph of the genus Lilium, mentions the introduction of the same variety from Japan into Great Britain at about the same period. He also states that the *Lilium longiflorum* was introduced into Great Britain by the Royal Horticultural Society in 1819. *Lilium harrisii* has the distinction of coming into bloom much earlier than the true *L. longiflorum* with similar treatment. It is probably the type of *L. longiflorum* which is found farthest south in the region where that species is indigenous. This region comprises southern and central China, the Riu Kiu Islands, and south Japan.

From small beginnings a little more than twenty years ago, the Easter-lily industry has assumed vast proportions in recent years. In Bermuda more than 3,000,000 bulbs are exported annually to the United States. In Japan, at the present day, millions of bulbs are grown from seed each year, the demand being so large that enough can not be grown from vegetative reproduction. But, unfortunately, up to the present time there has been no selection from the seedlings. This is the reason why with each importation from Japan many bulbs are found which, when the plants begin to bloom, lack uniformity in size of stem, time of flowering, and other characteristics. It is reported that the Japanese department of agriculture has taken the matter in hand, with a view to inducing the growers to weed out inferior seedlings and propagate only from the best. It is owing principally to the decadence of the Bermuda crop that the demand for bulbs, chiefly of *L. longiflorum* from Japan, has increased so very markedly in recent years. In 1879 the value of the bulbs exported from that

country was $2,500; in 1895, $40,000. In 1899, however, the figures jumped to $130,000, and the increase during the past three seasons has doubtless made corresponding strides.

VARIETIES OF LILIUM LONGIFLORUM FROM JAPAN.

The bulbs imported from Japan are chiefly *L. longiflorum*. Among them are several distinct varieties which differ from each other principally in the periods of blooming, but also in foliage, flowers, and general habit. Some have the leaves close together on the stem, the longest and broadest at the base, gradually shortening as the summit is reached. (See Pl. II, fig. 1.) Others have broad leaves, not so numerous as in the case of the plant just mentioned and with less difference in breadth and length between those at the base of the stem and those near the apex (Pl. II, figs. 2 and 3.) Some of the forms appear to be of a fixed type so far as scarcity of blooms is concerned. This is attributed to seedling stock raised from unselected parentage and the failure to breed continuously from the most desirable of the seedling plants. If this is the case, as there is good evidence to suppose, it is little wonder that the imported stock lacks uniformity in many of the most desirable characteristics.

Among the numerous forms there is one which shows great superiority over the others. In every respect it may be regarded as an ideal lily. It is said to have been found in a certain locality in Japan and named after the place where it was discovered. It is offered by two dealers under the names *L. longiflorum giganteum* and *L. longiflorum eximeum giganteum*. It is said to be a difficult subject to propagate vegetatively; consequently it is higher priced than any of the others. Some years ago when first sent to this country it was thought to be a natural hybrid between *L. longiflorum* and *L. brownii*. The leaves of this variety are not as numerous as in some varieties of *L. longiflorum*; they gradually taper from base to summit, but in this respect are not as pronounced as in some other forms. The stem for several inches above the base is of a blackish-brown color. The flowers are graceful in shape, the tube is short, and the diameter across the perianth is large. The texture of the flower is much firmer than that of any other cultivated lily, and the color is of a dazzling clear white. Either on the plant or in a cut state the flowers, by reason of their thick texture, last longer than those of any other form of *L. longiflorum*. With regard to the time it takes to force, it occupies a position in this respect midway between *L. longiflorum* and *L. harrisii*. Unfortunately, however, disease is quite as prevalent in this form as in others. Therefore, the propagation of the limited amount of stock available by scales, offsets, or division, and under the same conditions

as those existing in the Bermudas will be accompanied with no better results than are found in the *L. harrisii* product of the island. A bright future for this plant is predicted, not only on its individual merits but also as a parent, both male and female, from which to raise new forms through crossing with other varieties of *L. longiflorum*.

In the greenhouses of the Department of Agriculture there are at present several combinations between this plant and the most approved forms of *L. harrisii*. The plants are still in the seedling stage, but they will be watched with very great interest to determine the results of careful cross fertilization with the other varieties. Although the plants are so small that 100 could easily be put inside of a thimble, they are expected to flower within seven months.

Some bulbs of this little-known variety which were planted out in the open during the autumn of 1901 along with other *L. longiflorum* and *L. harrisii* plants, to test their hardiness and blooming periods and also to learn of their adaptability to the soil of this section, showed that they were not only hardy, but that the blooming period was ten days in advance of the earliest of the *L. longiflorum*. The bulbs planted were small and when lifted, during the latter part of August, were found to have increased considerably in size, besides making several small bulbs at the bases of the stems. The soil used is composed of friable loam, having been under cultivation a long time, but no manure had been given within two years before planting. Two dry spells occurred during the period of growth and this retarded their development to some extent.

DETERIORATION OF THE BERMUDA AND JAPAN GROWN LILIES.

Owing to the frequent and constantly increasing number of complaints relative to the diseased condition of the Bermuda and Japan-grown Easter lilies, the growers of this country are confronted with a condition to which considerable attention has already been given with a view to mitigating the troubles with which they have to contend in forcing the bulbs into bloom. When it is considered that probably over 5,000,000 lily bulbs are forced into flower during the winter and spring months, it will be seen that the crop is of great value; but notwitstanding all that has been done, the experiences of the principal greenhouse men indicate that the profits are very much curtailed owing to the diseased condition of the plants.

This disease shows its presence by the leaves becoming more or less discolored and the shape of the leaf altered so as to appear twisted. The flowers also lack the usual form and substance and the whole plant is dwarfed. When in bloom, if it ever reaches that stage, the diseased plant does not bring one-fourth of the price obtainable for a

healthy plant. During the past year complaints have been received from some of the largest growers that of their plants the bulbs of which were obtained from Japan and Bermuda from 20 to 60 per cent were diseased, and almost all of these were unsalable.

The causes of the diseased condition of the plants have been investigated by the best pathologists in this country and in Europe. Mr. A. F. Woods, Pathologist and Physiologist of the Bureau of Plant Industry, U. S. Department of Agriculture, issued a bulletin in 1897 giving the result of his investigations of the lily disease.[a] In this work the causes of the disease are discussed and remedies suggested. The florists of this country, however, who force the lilies have not the remedies in their own hands, as the disease is present in the bulbs before they are imported. In a later paper Mr. Woods has discussed the relation of nutrition to the health of plants, with special reference to *Lilium harrisii*.[b]

Lily growing on the Bermuda Islands is an exceedingly profitable industry. Practically all the land available for the production of bulbs is utilized for this purpose, and while the rotation of crops, together with the most approved methods of selection and cultivation, would undoubtedly be eventually a good policy for the growers to pursue, yet, except in the case of the more progressive growers, there is little likelihood of this being done, as it would materially decrease the revenue from lily farming for the time being. This will readily be understood when it is stated that an acre of lilies will bring from $1,000 to $2,000. Some growers on the islands who thoroughly appreciate the importance of careful methods are using small bulbs in preference to scales, and are selecting and fertilizing carefully, but they are heavily handicapped by the many small growers who cultivate their crops according to old methods; and in these cases there is no selection with a view to producing and perpetuating good types. Little manure is given. The methods of propagation are very faulty and they have not been changed since the beginning of the industry in the islands. For instance, in the growing of the bulbs for American markets the smaller sizes are planted in the fall and harvested in July, or before the bulbs have thoroughly ripened. In the process of handling, many of the immature scales drop from the bulbs. These are not thrown away, as they ought to be, but are carefully saved and planted with a view to raising small bulbs. These bulbs ultimately form a large part of the general crop.

As a result of some investigations made by the United States Department of Agriculture, it has been shown that by the use of seeds instead

[a] Bulletin No. 14, Vegetable Physiology and Pathology, U. S. Department of Agriculture, 1897.

[b] Yearbook U. S. Department of Agriculture, 1901, pp. 155–176.

of scales larger bulbs can be secured in a much shorter time than can be produced by the scale method. If the general crop were raised from seeds there would be a saving of at least a year in the production of a marketable bulb. Moreover, it has been demonstrated that in this way plants can be grown which are entirely free from disease, and, most important of all, that the seedlings give an opportunity to select better types than exist at the present time.

RECENT EFFORTS TO CULTIVATE THE EASTER LILY IN THE UNITED STATES.

For some years efforts have been made to cultivate successfully the Easter lily in the Southeastern States. This work is of considerable value in showing future growers what to avoid, but it has so far not been demonstrated that the lily, with the methods used, can be grown to compete with the foreign product. Not only are the bulbs late in ripening, but when harvested they seldom show any increase in size over that at the time of planting. The cultivation of the lily in the Southern States has evidently been conducted with a view to producing bulbs which would ripen in July, or early enough to compete with the Bermuda-grown product. This result has not been accomplished, and with a continuance of the same cultural methods it is not likely to be. Furthermore, a practice which has undoubtedly contributed somewhat to this lack of success consists in using the stock as received from the Bermudas and Japan. It is admitted that in the Southeastern States the climate is not as favorable for the bulbs as it is in the countries mentioned; therefore, it follows that early planted bulbs starting into growth during the warm days of autumn and weakened by the cold spells of winter will fall an easy prey to the diseases present in the imported bulbs when planted. If success is to be attained in the future in producing bulbs of marketable size, it must be with different methods and along entirely different lines from those followed in the past.

It has been demonstrated by Mr. A. F. Woods, of the Bureau of Plant Industry, that bulbs of the Easter lily can be carried over a season in cold storage. Not only is this operation a success in itself, but it has resulted in showing that the bulbs are benefited very materially by this treatment, as it subjects them to a condition to a certain extent approaching that existing in Japan, the native country of the species, where the bulbs are heavily covered with snow during the resting period. This fact opens up new possibilities in the cultivation of the lily. Heretofore, bulbs have been planted in some parts of the South early in the fall, with the result that they sprouted considerably before cool weather set in. In fact, the growth made at a certain period was

quite as far advanced as that in Bermuda at the same date; but the climatic and soil conditions being so different in the South from those prevailing in Bermuda, the results were more or less disastrous. The growth above ground, where the plant was not killed outright, was more or less injured by cold and other generally unfavorable conditions. During the period before coming into bloom, the plants rendered sickly during the winter often suffered severely from lack of moisture, resulting in poorly developed bulbs.

So far, practically nothing has been done in experimental work with a view to giving the bulbs the most favorable conditions to develop, leaving out of consideration altogether early ripening for forcing the following fall. It is the intention of the Department of Agriculture to work with this end in view, not only in the South but in the Middle and Northern States and also in the West.

A knowledge of the proper time to plant the bulbs in the various sections of the country in order to produce a bulb of maximum size in as short a time as possible but in a thoroughly ripe condition before being harvested is most important, and this knowledge is to be gained only by carefully conducted trials. Every florist who is interested should experiment in a small way to ascertain how the bulbs will succeed out of doors in his section of the country.

The soil problem does not present many difficulties beyond the selection of well-drained situations and a light, sandy loam, which can be kept sufficiently moist during the growing season to prevent the plants from receiving a check. Treatment should be accorded a portion of the bulbs similar to that found to succeed with bulbs of the other species of *Lilium*, such as *L. auratum*. This consists in placing in the vicinity of the bulb, moss or other material which will retain more moisture than the surrounding soil. During dry weather this is found to be an excellent provision for supplying the growing roots with moisture until a fresh supply is received from rains and until the roots penetrate deeply into the ground, so as to withstand dry spells. In trials of this nature the bulbs should be allowed to stay as long as possible in the ground after the tops decay. They should be harvested just before there is danger of their beginning growth for the following season, because any interference that tends to cause premature shriveling and decay of the thick roots near the base of the bulb, such as harvesting before natural ripening occurs, invariably occasions a shrinkage of the tissue of the outer scales and incidentally provides a ready means of ingress for fungi and bacteria to the tissue of the bulb through the ruptured tissue of the roots. This condition of premature decay, while the bulbs of the field are subjected to moisture, even for a short time, provides favorable harbors for mites, which, although their purpose at first may be merely to feed on the decaying tissues

and act as scavengers, will ultimately injure what remains of the bulb by attacking the living tissues, rendering the bulb more susceptible to other maladies. Thus by a system of vegetative reproduction, the bulbs, even though they be in a healthy condition and free from disease of all kinds previous to lifting, may afford by careless harvesting a lodgment for various enemies and give opportunities favorable for disease year after year.

LINES OF INVESTIGATION CARRIED ON BY THE DEPARTMENT OF AGRICULTURE.

That the progress of the disease is accelerated through the present methods of handling and cultivation is shown by the fact that in the Bermudas there are private gardens in which the lily has been undisturbed for years where the plants grown show no trace of disease. The recent investigations by Mr. A. F. Woods show that the disease is due to several causes, and may be brought about by a weakened condition through improper harvesting, resulting in the attacks of mites, fungi, and bacteria. There is nothing to indicate just how long it would take to rid the plants of the disease by giving proper treatment in the Bermudas, but the easiest way out of the difficulty appears to be in raising and selecting stock plants not from scales, but from seeds, and in planting the bulbs within our own borders, where, if given the care which the crop demands, there is every reason to expect that the difficulty will be solved in the near future.

In a large number of seedlings at least 50 per cent can be counted upon to possess desirable characteristics, which will be shown the first year following that in which the seed is sown by the plants coming into flower. The remainder can, if it is thought necessary, be discarded and the good ones grown on for forcing, the size necessary for which will be attained the season following, or within two years from the time the seeds are sown. The very best of these seedlings, some of which will undoubtedly show superiority in several ways over the parents, can be retained for seed, and by keeping up the system of selection there will develop in a very few years strains from seed which will be superior to most of the plants placed upon the market at the present day.

In beginning the work of bulb growing in the United States along entirely new lines there seemed little probability of securing stock from the Bermudas or Japan for vegetative reproduction, which could be relied upon as absolutely free from disease. There are localities in the Bermudas where lilies are growing which appear to be quite healthy; there is, however, a danger of the bulbs being more or less contaminated, owing to the close proximity of the districts where the

diseased bulbs are grown. Therefore recourse must be had to some method other than vegetative reproduction from foreign-grown bulbs.

The beginning of the experimental work along this line has been carried on with the utmost care. Several bulbs of the true *L. longiflorum* and its principal forms were secured. These bulbs showed no indications of the presence of the disease by the usual diagnosis. As the growth above ground developed, those plants which in any way showed signs of abnormal development were removed from the greenhouse and destroyed. A rigid process of selection was carried on up to the time the plants came into flower, with the result that at the blooming period the various groups were made up of fine specimens of the several types of *L. longiflorum*. These were *L. l. eximeum*, otherwise *L. harrisii*, *L. l. latifolium*, *L. l. multiflorum* and *L. l. eximeum giganteum*. Each group was kept separate from the others so that there should be no likelihood of accidental intercrossing. Those plants which were selected as seed bearers were emasculated while the anthers were still immature. In no case was a plant allowed to have a flower fertilized by its own pollen or even from that of other flowers on the same plant. In this way the chances are the greater that the resulting seedlings will show more vigor than if each flower had been self-pollinated, or if pollen had been transferred from one flower to others on the same plant.

A series of crosses were effected between differing forms, which it is hoped will result in securing types different from those now in cultivation. The flowers of several plants of *L. longiflorum* were fecundated with pollen taken from flowers of *L. harrisii*, and vice versa. The seedlings from these crosses have already flowered, and the results are very satisfactory. They are especially valuable in pointing out future work along the same lines. The progress made by the seedlings as a result of these crosses is somewhat remarkable, in that they bore flowers in a comparatively short time after germinating. Plate III shows the capsules and seeds of *L. harrisii* crossed with *L. longiflorum*. Plate VII represents the different stages of germination. In Plate IV, fig. 1, the seedlings are in 2-inch pots, about five weeks after making their appearance above the soil. In three of the seedlings the seed coats are seen adhering to the ends of the seed leaves. A later stage is indicated in Plate IV, fig. 2, where the seedlings are more advanced, having made from two to four character leaves. This represents the progress made in ten weeks after germinating. From this stage onward the growth is quite rapid.

In Plate V, fig. 1, is seen a seedling with all the radical leaves showing, but not fully developed. This is the stage just previous to the development of the flower stem. The bulb at this period is nearly 3 inches

in circumference and is wholly formed of the bases of the leaves. This particular bulb was in no way injured by the soil being washed from the roots; it was repotted and formed a stem, which bore two flowers.

Of the two seedlings in flower (Pl. I) the one to the left, marked "A," is *L. longiflorum*, crossed with *L. harrisii;* that to the right, marked "B," is the reciprocal cross. There is a very marked difference in the size of the flowers, the one to the right being fully 2 inches longer than the other. This difference was observable in nearly all of the individuals of the *L. harrisii* × *L. longiflorum* batch.

The bulbs shown in Plate V, fig. 2, are the largest which were formed. They belong to the *L. harrisii* × *L. longiflorum* batch and were harvested on the 15th of August, ten months and fourteen days after the seeds germinated. The bulb to the right measured 6 inches in circumference. Each of the plants bore three average-sized flowers. It will be seen that the bulb formed as in Plate V, fig. 1, has disappeared, and new bulbs with true scales have formed at the bases of the stems.

PLANTING IN THE OPEN GROUND.

Batches of lilies for experimental work in ascertaining localities favorable to the production of bulbs should be planted late or early according to the particular section of the country in which the experiment is to be conducted. In the North it may be considered safe to put them in the ground during the latter half of September. Farther south the planting should be delayed so that there may be no danger of the growth showing above ground previous to freezing weather.

In the North as hard freezing weather approaches the ground in which the bulbs are planted should have a heavy mulch of such a nature as to be easily removed in spring. This mulch will serve several purposes; it will help to keep the soil around the bulb at an equable temperature and prevent rapid thawing and freezing at and near the surface of the soil. Throughout the South, especially in the districts within the frost belt, the mulch need not be heavy, and should consist of half-decayed leaves or very old manure, so that there will exist no necessity for its removal when the growths are making their way through the soil. It should not be applied too soon, as there is then a danger of the soil being kept too warm, thus encouraging the shoots to push above the soil before the advent of cold weather. In all cases a mulch should be spread over the soil during hot, dry weather.

So far as the requirements of the lilies are understood, correct conditions would not be supplied by repeated cultivation between the rows. Those conditions could be secured best by a system of mulching

to keep the sun from warming the soil too much near the surface or else by the substitution of some kind of a shade crop to protect the soil from the sun's rays. This crop would, of course, have to be of such a nature as not to rob the soil of too much of the food and moisture necessary for the growth of the lilies.

Again, the bulbs may be grown in beds, as in the Bermudas, and close enough together to shade the ground to a certain extent. In any event, the cool and fairly moist condition of the surface soil is a most essential point to be observed in the cultivation of the lily. In planting, the depth to which the bulbs should be placed should range from 4 to 6 inches, according to the size of 1-year-old bulbs.

In this, as in every other crop, there are so many details essential to successful cultivation, all differing with the localities, that the above directions must be construed merely as suggestions. Lily farming in the United States is so new that one must not be discouraged if at first failure results from treatment which applied to most other crops would mean success.

REPRODUCTION FROM SEED.

A point greatly in favor of raising *L. longiflorum*, *L. harrisii*, or any of the other forms from seed, to constitute the crop of marketable bulbs, is that from one to two years' time is saved in the operation over the scale method. This in itself will appeal to most people; but it is by no means the best feature of the method, as will be shown later on.

Plate V, fig. 2, shows bulbs which measured 6 inches in circumference at a period only ten months after the seeds germinated. These bulbs each produced three flowers above the average size. Much poorer plants are sometimes retailed at $1 each. So easy is it to raise flowering plants from seed that the writer is inclined to believe that should the time come when the disease is more rampant than at present, growers will, when the subject is better understood, be able to raise their own bulbs by a system of greenhouse treatment and have the plants from seed flowering in pots ready to be sold within a year.

This would probably seem like a fairy tale to the participants of the lily conference held in London in 1901. One of the papers read at that time states that many species of *Lilium* must have from ten to twelve years to develop a flowering bulb from the seed. Elwes, in his Monograph of the Genus Lilium, says of *L. longiflorum:* "In three or four years at most flowering bulbs will be produced from seed if the young plants are properly treated." This means that by the English method of raising seedlings the plants in flower take five years at most to reach that stage.

There exists a widespread belief that in raising plants from seed a long time elapses before they come into bloom, and it is urged against the seed method that a certain percentage of the plants in a batch are late in coming into flower. It should be remembered, however, that this is more or less the case with all kinds of plants where the method of vegetative reproduction is suddenly changed to that of reproduction from seed. In all cases this irregularity of the blooming period lasts only for a time.

There is a possibility of fixing types in seedling lilies as in all other plants raised from seed, but just how long a time would elapse before this desired result would be attained has not been determined. A few generations would probably cover the period.

But even were there no possibilities of fixing types from seminal reproduction, the supposition that this method of propagation is a drawback because of late bloomers is very erroneous. This point has been raised against the method chiefly because it has never been tried systematically. A batch has been raised giving only about 75 per cent of bulbs that can be depended upon to produce plants that will open their flowers within, say, a period of ten days; but even so, with the gain of increased vigor and the saving of time required in the production of a marketable bulb, it will pay handsomely, even if the late bloomers are discarded while in the growing stage in the field and only the early blooming bulbs are harvested. However, there is no necessity for so radical a treatment. The early bloomers can be separated from those which bloom late, and sold accordingly. There is a demand for healthy bulbs at whatever time they bloom. Furthermore, by judicious selection of seed parents—that is, those which come earliest into bloom, having other desirable characteristics to recommend them—and by careful cross-fertilization of these forms there is an absolute certainty of fixing types which will be satisfactory in every respect.

Nearly every lily has been propagated asexually up to the present time, and the system is, to a certain extent, answerable for the wretched condition of the crops, which, even with intelligent care in our greenhouses, show from 40 to 60 per cent of diseased plants. Most growers would greatly prefer to have only 25 per cent of late bloomers in a batch of healthy bulbs from seed than that the present conditions affecting the Bermuda and Japan bulbs should continue.

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EMASCULATING AND POLLINATING THE FLOWERS.

To raise seedlings of any desirable variety of *Lilium longiflorum* which will reproduce as nearly as possible the same characters possessed by the parents, it is necessary to take precautions against the possibility of pollen from less desirable forms being deposited upon the stigmas of the flowers selected to bear seed. In the flower of the Easter lily the anthers reach maturity a little in advance of the period when the stigma is in a receptive condition. The early ripening of the pollen and the large size of the anthers make it easy to remove the stamens at quite an early stage in the life of the flower.

Emasculation can be performed with a certain degree of safety after the perianth segments expand, but it is accomplished with greater certainty while the flower is in the bud stage. When the operation is performed early it seems to divert to the pistil the substance which otherwise would be utilized in the development of the stamens. Thus, if the stamens are allowed to remain and pollinate the same flower with its own pollen, or that from the flower of another individual, the resulting capsule of seed is smaller than that borne by an artificially pollinated flower which had previously been emasculated. To remove the stamens at an early stage it is necessary to cut off one or two divisions of the perianth for at least one-third of their length. The stamens, being very large, are then easily removed with the aid of a pair of forceps. The condition of the stigma most favorable for the reception of the pollen is indicated by its having acquired full size and by its color changing from a greenish white to creamy white. This period occurs just before the surface of the stigma is copiously covered with a viscid secretion. Before the secretion appears the pollen takes immediate effect. Fecundation, when successful, is indicated by the rapid withering of the perianth; also by the ovary, which, in a few days, will assume a vertical position instead of remaining horizontal. (Pl. II, figs. 1 and 2.) In this position it will continue, in the absence of fertilization, until it falls off or withers.

It is of importance that the actual work of applying pollen from the anthers of one flower to the stigma of another be performed during the early part of the day, choosing a time when the sun is likely to be unobscured for several hours. The air should also be dry and warm. It is not necessary to use a brush in transferring the pollen. With a pair of forceps an anther may be removed by severing a filament at about half an inch below the point of attachment. The pollen grains on a single anther are sufficient to cover thoroughly the surface of the stigma. While held by the forceps the anther should be rubbed against the stigma until the latter is covered with the pollen grains. This condition is easily observed by the bright yellow color

and copious supply of pollen. The pollinated flower should not be covered with paper bags. These, as a rule, serve well with other kinds of flowers where artificial pollination is resorted to in keeping out insects and preventing pollen being brought by other agencies, but in the flowers of Lilium they are usually hurtful, because the atmosphere surrounding the stigma is to a certain extent stagnant on account of the thick texture of the paper interfering with the free admission of air. If this condition is present while the very copious secretion is over the large stigma, some of the pollen grains decay, and the result is that a moldy growth will occur over the entire pollinated surface. Light gauze or cheese-cloth bags will be found excellent substitutes for paper bags. There is little probability of pollen grains being carried about by a movement of the atmosphere or the visitations of insects, but it is better to guard against the danger of undesirable pollen gaining access to the stigma.

In all of the varieties the seed vessels take from eight to ten weeks to reach maturity. This is indicated by a change of color from pea-green to a light straw-colored hue, at first near the apex, then gradually extending toward the base. When the basal part changes its color the seeds are ripe. The seed vessel at this stage begins to dehisce, starting at the apex and splitting into three parts, each part containing two rows of seed closely arranged lengthwise. When the vessels begin to open they should be gathered and kept in an uncovered receptacle until most of the moisture in the walls of the seed vessel has evaporated. In a day or two the seeds must be removed from the capsules. They are then damp to the touch and should not be excluded from the air while in this state, as there is danger of their becoming moldy. They should be spread out on trays for a day or so to dry. Afterwards they can be kept in jars until wanted for sowing.

SOWING THE SEEDS.

In places having a similar winter climate to that of the Bermudas, or where the minimum temperature does not fall below 45° F., the seedlings may be raised out of doors without the aid of greenhouse structures but with the protection of sash throughout the germinating period and until the plants have made the first three or four leaves.

The plants can be brought to this stage by the beginning of September and transferred to convenient distances apart in beds, where they will make rapid growth. The seeds should be sown in beds in rows from 5 to 6 feet wide. To have the soil in which the seed is to be sown of sufficient warmth to promote a steady growth, there should be at least 3 inches of stable litter and leaves placed in the bottom of the bed. Loamy soil, mixed with one-third vegetable humus, should

be placed over the litter to a depth of at least 6 inches. This should be well firmed and raked smooth. The seed should be sown quite thickly, as the seedlings have small, narrow leaves and occupy but little space until they are ready for pricking off. After the surface of the seed bed has been raked quite smooth the seeds should be sown evenly over the bed, from 6 to 10 to each square inch of surface, according to the quality of the seed. The seeds can be pressed into the soil with the back part of a spade or a smooth piece of board and covered with one-half inch of sifted and sterilized soil composed of loam and leaf soil in equal parts. The soil, if sterilized, will prevent the disturbance of the surface in removing weeds. The surface should be pressed moderately firm and watered with a fine sprinkler only when the soil appears to be on the dry side. The surface of the bed can be kept in excellent condition for successful germination by covering it with an inch of sphagnum moss, which should be sprinkled occasionally, and the soil should be examined frequently to ascertain its condition.

The seeds require a considerable time in the ground before the first leaf appears above the surface. Therefore, to provide seedling plants for a large crop the seed beds will occupy a comparatively small space. They will thus be easily tended, so far as watering, shading, and weeding are concerned, until the seedlings have attained sufficient size to warrant pricking off. If bulbs are planted and seeds sown at the same time, the bulbs naturally can be flowered quicker than the seedlings, but only by a few weeks. Therefore, the seeds should be sown early—say, during the month of June. When sown at this period the seedlings will attain a fair size during warm weather, and will all the better be able to withstand the lower temperature of the winter months.

With regard to raising seedlings in the Middle and Northern States, there is little probability of success unless the seed is sown, say, during the month of January indoors and the seedlings are transplanted to outdoor beds as soon as the weather permits. For experiments of this nature the seeds would necessarily have to be of the previous season's crop, and in order to have them ripen late, so that as short a time as possible would elapse between ripening and sowing, the seed-bearing plants should be grown outdoors.

PRICKING OFF THE SEEDLINGS.

The seedlings will bear pricking off as soon as the seed leaves reach full size. Nothing is gained, however, by undertaking the operation at this early stage. It is more easily accomplished after the plantlets have made two or three leaves. They should be transferred to beds

similar in size to those in which the seeds were sown and at a distance of from 2 to 3 inches apart. The work of pricking off can be very rapidly done, and wholly with the fingers or without the aid of a dibble. The protection of shaded sash may be given for the first few days if found necessary. When the plants are supplied with leaves of such size as to be in danger of crowding each other they should be removed to the field beds. It may be stated that the plants, even in their younger stages, are not at all impatient of removal. Plate V, fig. 1, shows a plant which was grown in a 5-inch pot, the soil being removed from the roots to show the size of bulb at a certain date from germinating. This bulb was repotted and came into flower seemingly none the worse for its experience.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Frontispiece.—Seedling lilies in bloom. A.—*Lilium longiflorum* × *L. harrisii*. B.—*Lilium harrisii* × *L. longiflorum*, showing large flower. Photographed April 16, 1902, six months and thirteen days after germinating.

II. Fig. 1.—*Lilium longiflorum*, tall-growing variety from Japan, showing the vertical position assumed by the ovaries after fertilization. Fig. 2.—*Lilium longiflorum*, low-growing variety from Japan, with long, broad leaves. The capsules show the progress made at a period of three weeks after pollination. Fig. 3.—*Lilium longiflorum*, tall-growing variety from Japan, with long and broad leaves along the entire length of the stem.

III. Capsules and seeds of *Lilium harrisii* × *L. longiflorum*. Flowers pollinated April 3; seeds ripe June 14, 1901.

IV. Fig. 1.—*Lilium harrisii* × *L. longiflorum* seedlings in 2-inch pots. Seeds sown June 26, 1901, germinated October 3, potted October 28, photographed November 9, 1901. Fig. 2.—*Lilium harrisii* × *L. longiflorum* seedlings in 2½-inch pots ten weeks after germination.

V. Fig. 1.—*Lilium harrisii* × *L. longiflorum*, showing size of bulb February 16, 1902, eighteen weeks after germination. Fig. 2.—Seedling bulbs of *L. harrisii* × *L. longiflorum*. The bulb to the right measured 6 inches in circumference. These bulbs were grown from the seed within ten months.

VI. Diseased Bermuda lily bulbs. A.—Cross section through a diseased bulb that began to grow and then died. The tissue was eaten out by the bulb mites. B.—Cross section through a bulb that failed to grow. The bud was eaten out by mites.

VII. Germination of *Lilium longiflorum*. 1. Sprouting of the seed. 2. An older stage, where the cotyledon shows the bending, while the apex remains closed in the seed absorbing the endosperm. 3. Still older. 4. The cotyledon has now unfolded itself, raising the attached seed high above the level of the ground. 5. The first leaf *l'* is developed while the cotyledon is as above. 6. The seed has dropped and three leaves are now developed; also two secondary roots. The roots show wrinklings above, indicating their contractile power in drawing the bulblet deeper and deeper into the soil.

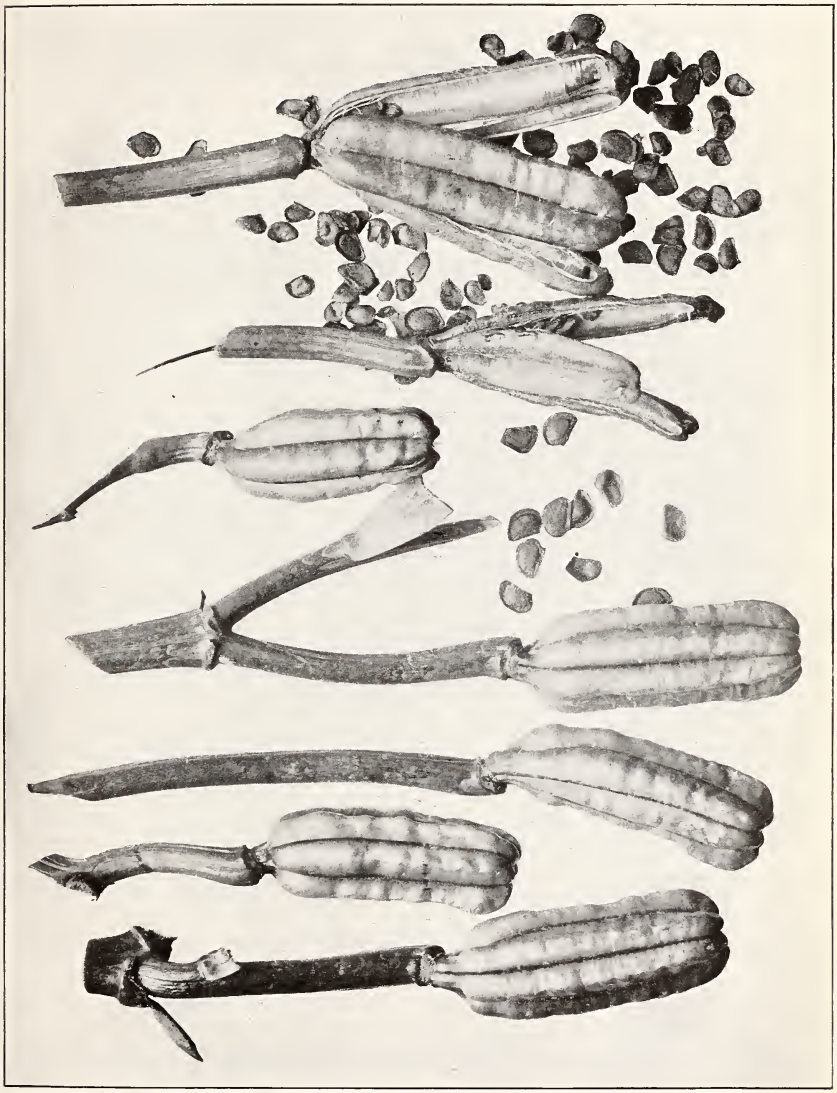
Fig. 1.

Fig. 2.

Fig. 3.

LILIUM LONGIFLORUM.

Figs. 1 and 3, Tall-growing variety from Japan; Fig. 2, Low-growing variety from Japan.



CAPSULES AND SEEDS OF LILIUM HARRISII × L. LONGIFLORUM.

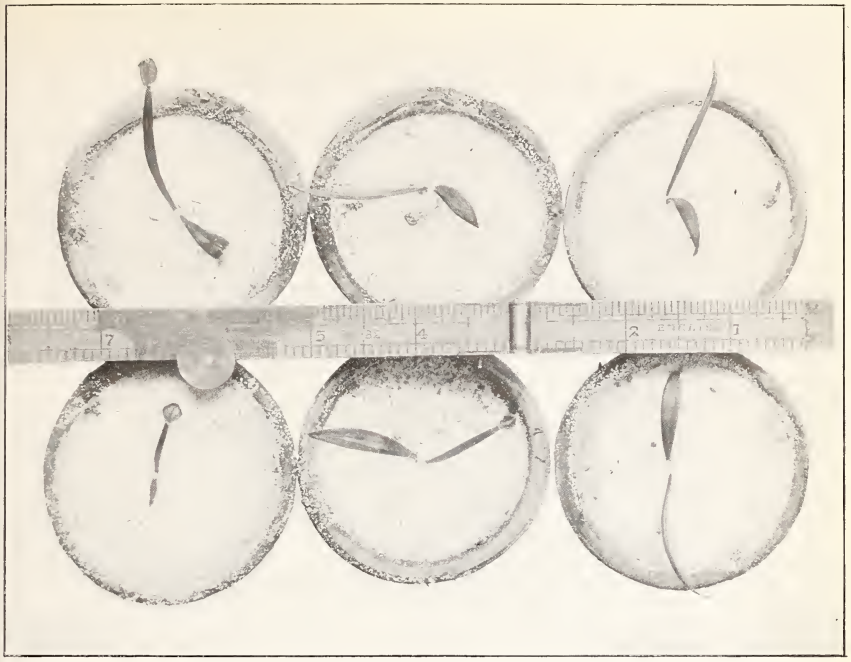


FIG. 1.—LILIUM HARRISII × L. LONGIFLORUM SEEDLINGS IN 2-INCH POTS, FIVE WEEKS AFTER GERMINATION.

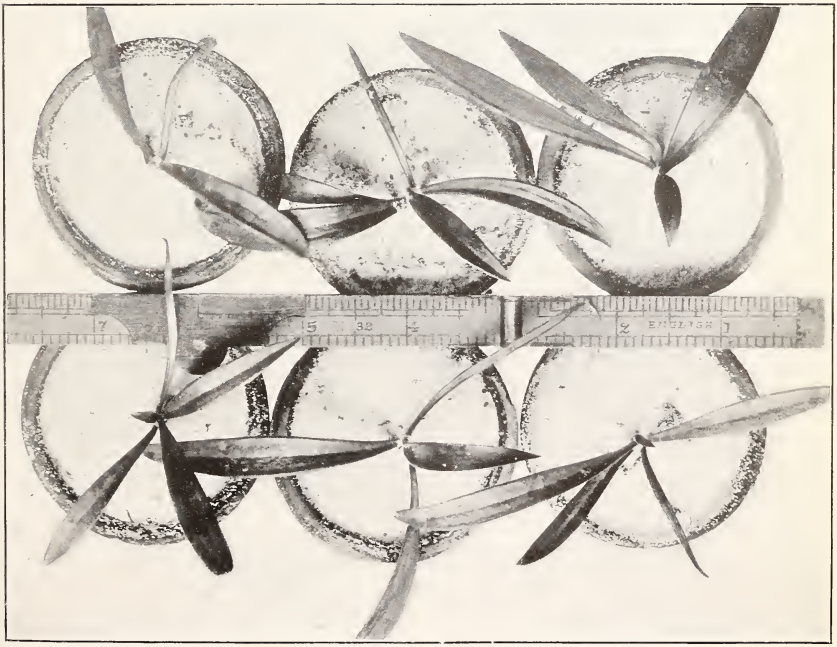


FIG. 2.—LILIUM HARRISII × L. LONGIFLORUM SEEDLINGS IN 2½-INCH POTS, TEN WEEKS AFTER GERMINATION.

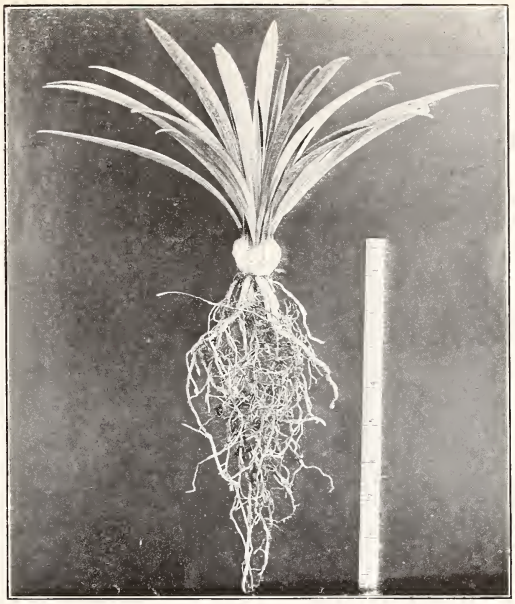
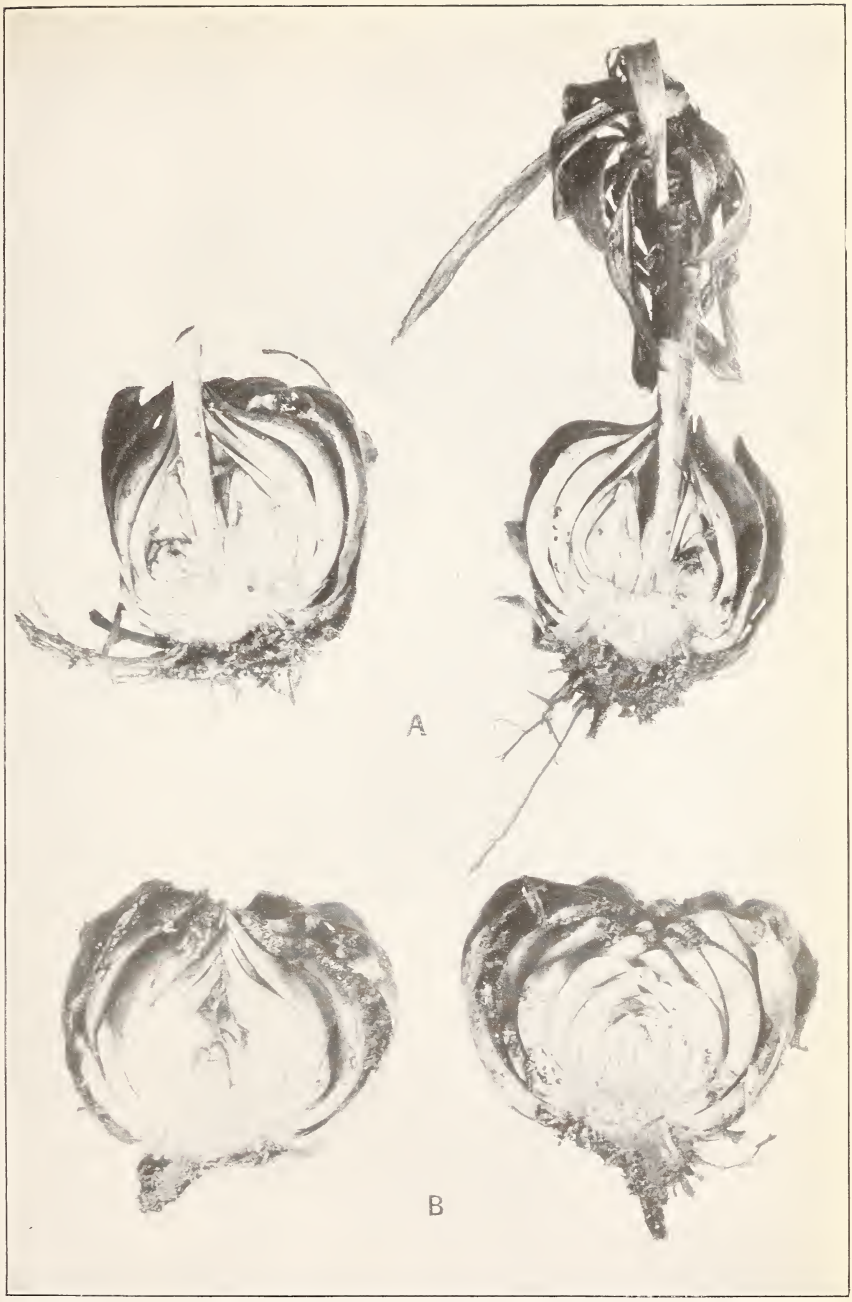


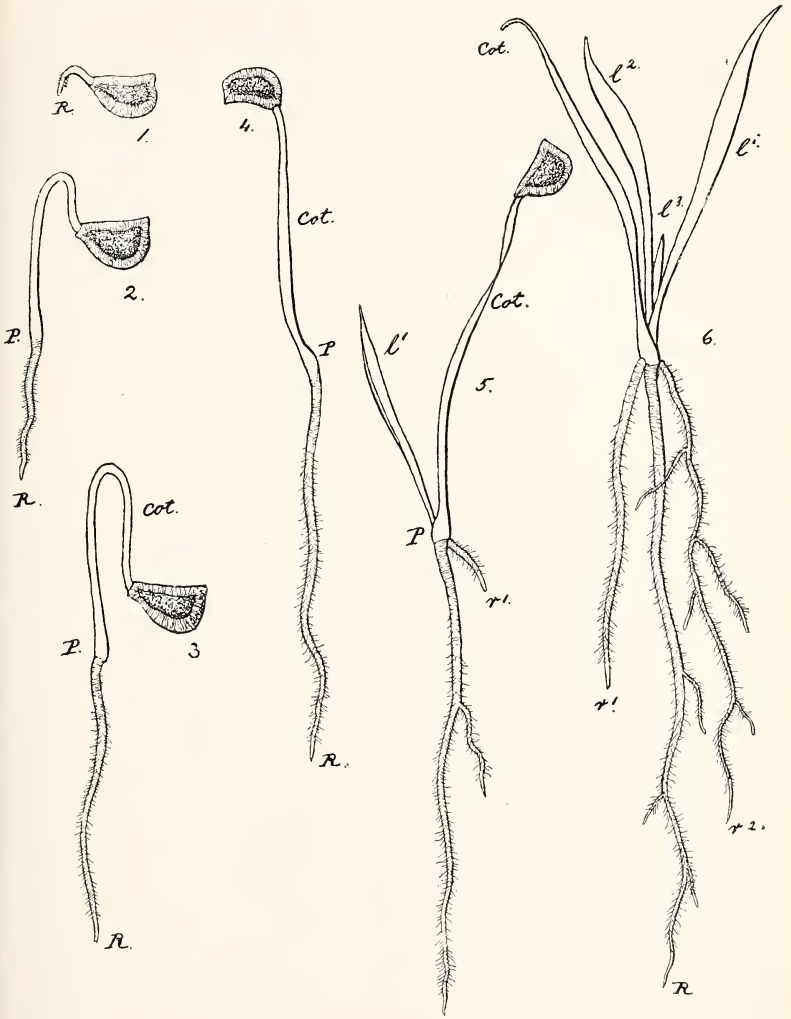
FIG. 1.—LILIUM HARRISII × L. LONGIFLORUM, SHOWING BULB EIGHTEEN WEEKS AFTER GERMINATION.

FIG. 2.—SEEDLING BULBS OF LILIUM HARRISII × L. LONGIFLORUM, GROWN FROM SEED WITHIN TEN MONTHS.



DISEASED BERMUDA LILY BULBS.

A. Cross section of bulb that began to grow though the tissue was eaten by mites: *B*, Cross section of bulb, with bud eaten by mites, that failed to grow.



GERMINATION OF LILIUM LONGIFLORUM.